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PLATE XXI.

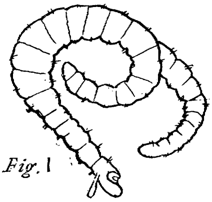

Fig. 1

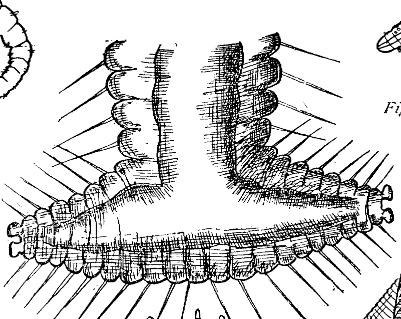

Fig. 2

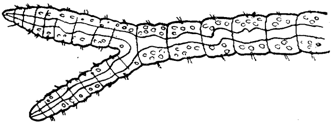

Fig. 3

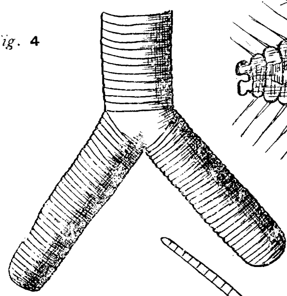

Fig. 4

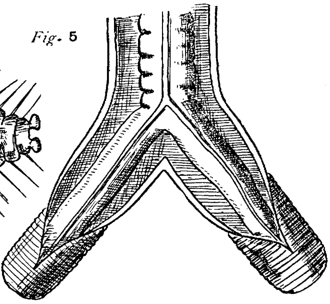

Fig. 5

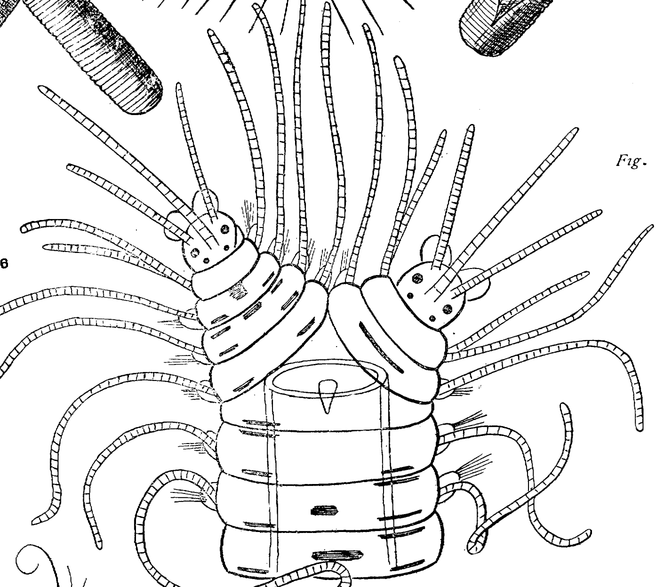

Fig. 6

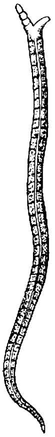

Fig. 7

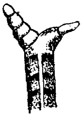

Fig. 8

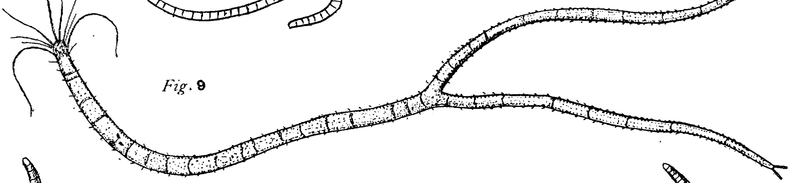

Fig. 9

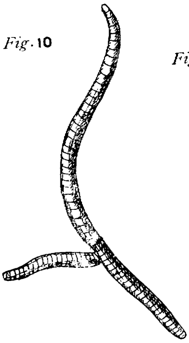

Fig. 10

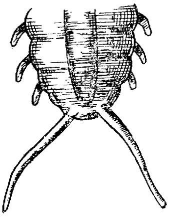

Fig. 11

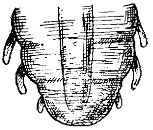

Fig. 12

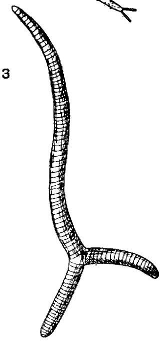

Fig. 13

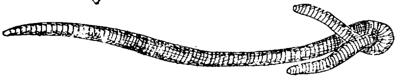

Fig. 14

Bifurcated Annelids.

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BIFURCATED ANNELIDS.

BY E. A. ANDREWS.

Abnormal structures among non-vertebrates have come under the observation of everyone who has carefully examined a large number of individuals in any group. Just as there are many cases of duplication of parts occurring among the higher vertebrates, so among the non-vertebrates we have recorded cases of the same nature. As might be expected, this tendency to produce supernumerary parts is most easily noticed in such groups as the crustacea, insects, echinoderms, where the nature of the skeleton aids in the recognition of abnormalities. Even among the soft-bodied animals, however, many cases of abnormal duplication of parts have been recorded.

For the group Annelida, such records are scattered and not generally known or accessible. To bring these together with the hope of eventually obtaining material for a more complete view and discussion is the object of the present article.

We will limit the review to cases in which the main axis of the worm is duplicated, to some extent, at one end of the body, so that the animal has there two left and two right sides, has either two heads or two tails.[1]

In the last quarter of the eighteenth century Charles Bonnet (**1**), while experimenting upon the power of regeneration in certain freshwater annelids (naiads) found that there was sometimes a sort of tubercle formed upon the body, leading, he imagined, to the formation of new individuals by stolon-like outgrowths! In one case an individual was cut into three pieces; the posterior piece formed a new head for itself and at the same time gave rise to one of these tubercles, which Bonnet regarded as a second head. This specimen is shown in fig. 7, and its bifid anterior end in fig. 8.

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[1] The author would be glad to receive references to literature upon this subject and if possible the privilege of examining specimens showing such bifurcations.

Such tubercles occurred at the posterior end also, and in one case, in another species of fresh-water annelid, two definite tails were observed. These two cases seem to have been the only ones noticed among very many individuals carefully observed during these experiments upon regeneration of parts after artificial section.

Towards the middle of the present century Edward Grube (**2**) cites the case observed by Schäffer, who had made unsuccessful attempts to obtain reproduction of lost parts in the fresh water annelid *Sænuris variegatus* Hoffm.

In this one case an individual with two definite tails was found a few weeks after Schäffer had cut the bodies of the annelids into pieces in the hope of having them form new ends.

More recently C. Bulow (**3**) made a long series of experiments upon the regeneration of lost parts in *Lumbriculus variegatus* Gr., and discovered among his specimens some cases in which there were two well-formed tails. In one individual, 5.5 cm. long, each tail was 1.75 cm. long.

About the same time Zeppelin (**9**) found three cases of bifurcated posterior end in the simple, perhaps primitive, annelid Ctenodrilus. Two of these are shown in figs. 1 and 3. These were obtained among several hundred specimens carefully examined in studying the peculiar reproduction by budding found in the Ctenodrilidæ. This process consists largely in the reproduction of lost parts after the animal has spontaneously divided itself into small pieces consisting of only a few somites.

The above cases of bifurcation of the main axis in aquatic oligochætous annelids have been discovered during special researches upon these small and not commonly observed animals. In their terrestrial allies, however, among the well known earthworms, cases of such striking monstrosities have fallen under the observation of many casual observers.

In Europe Charles Robertson (**4**) described and figured such a case in *Lumbricus terrestris.* As shown in figs. 4 and 5 the body is divided into two equal posterior parts, at the 85th somite. Each begins with a perfect somite and thus leaves a triangular membranous area on the dorsal and ventral sides of the trunk. The length to the fork was two inches ; that of each caudal portion $\frac{1}{8}$ inch. Each portion had about 20 somites and contained a portion of the forked intestine, chief blood vessels and nerve trunk ; had well developed setæ and a separate anus. The animal appeared to be an adult, having fully and normally developed sexual organs.

This description was drawn from an alcoholic specimen in the Oxford University Museum. F. Jeffrey Bell (**5**), however, had a live specimen of the same species under observation for two months. This was a small immature individual represented in figs. 10, 13 and 14, in which, however, the clitellum began to appear shortly before death. Before dying, the left tail, which was shorter, became less and less active and relatively shorter till finally both tails were thrown off or disappeared and death ensued.

He also observed a dead specimen of *L. fœtidus* in which there was a forked posterior end.

Horst (**6**), in experimenting upon regeneration of lost parts in earthworms, found one 100 mm. long with two tails, each 25 mm. long and quite normally formed. This again was a living specimen when observed.

On this side of the Atlantic, Asa Fitch (**7**) seems to have been the first to record the occurrences of such monstrosities. Among some interesting observations upon the habits of earthworms, regarded as *L. terrestris,* he records finding in his garden in New York State, a live specimen about three inches long with the posterior end divided for nearly one fourth of this length. These appendages are equal, but each only about two-thirds the normal thickness of the body anterior to them.

Each appendage possessed a functional anus. The left appendage appears as a continuation of the body, three somites serving to form a gradual transition from the thicker trunk to the thinner appendage. The right appendage springs out from the gaping suture between the trunk and the first of the three transitional left somites; where this origin of the right branch occurs there is a slight constriction not represented at all upon the left branch. The method of bifurcation seems thus similar to that figured by Robertson, fig. 4.

Very recently C. Dwight Marsh (8) records a two-tailed earthworm found in Wisconsin. While alive both tails appear of equal importance, but in alcohol one division is markedly constricted where it joins the body and appears as a mere lateral branch. Each appendage has a branch of the intestine and of the nerve trunk, as well as a functional anus. In alcohol the specimen is only 34 mm. long, the tails each 12 mm.

Among the marine polychætous annelids instances of duplication of the main axis have been recorded for several most widely separated families.

Thus amongst the sedentary Serpulidæ, Edouard Claparède (**10**) found a *Salmacina incrustans* in which the posterior end was bifurcated as in fig. 2, each part having an anus.

Among the nearly related family Sabellidæ, Brunette (**11**) found, in an unknown species of Branchiomma, one case in which there were two posterior ends, the smaller one making an angle of 30° with the larger. The smaller end is a newly formed one having the fæcal groove less marked than upon the older end, and the ventral shields scarcely visible. The whole annelid is small, 6 cm. x 6 mm., while the new posterior end is 1 cm. long and attached about 15 mm. from the tip of the older posterior end. Here then we have to do with a case of unequal bifurcation, one part appearing as a new formation grown out from the side of the normal animal near its posterior end.

Among the errant Polychætæ, in the family Syllidæ, Paul Langerhans (**12**) found a remarkable case of bifurcation, not of the posterior, but of the anterior end. This, the only well authenticated case of double-headedness amongst annelids, was seen in a specimen of *Typhlosyllis variegatus* Gr. from Madeira. As shown in fig. 6, the left head has two somites more than the right. As the author notes, and as the figure indicates, the specimen appears to have lost its original head and to have grown there two new ones, having been broken off just anterior to the pharyngeal tube. This, with its dentition, is of the normal size and could not be used in connection with either of the two small heads.

In the same family a case of bifurcation of the posterior end in *Procærea tardigrada* Wb. was observed in North Carolina by E. A. Andrews (**13**). Among several hundred specimens seen during two successive seasons two cases of such bifurcations seem to have occurred, one being found by Prof. Nachtreib. In the one represented in fig. 9 the animal moved actively, each long tail crawling like the normal termination of the body. Each has also the peculiar red transverse bands of this species. Though nearly equal in length and diameter the two tails have unequally perfected posterior tips, as seen in figs. 11 and 12, the right lacking the normal anal cirri. In fact this right tail was interpreted as a sort of lateral outgrowth from the more perfect left tail. This was one of the common non-sexual individuals in which the sexual head was forming upon the fourteenth somite as usual, preparatory to a separation of all the following region as a sexual individual, in this case, a female, which would then have two tails to burden it in its more active mature life.

The only other case that I find record of is that of a *Nereis pelagica,* observed by F. J. Bell (**14**), a specimen sent from Guernsey and exhibited at a meeting of the Zoological Society of London. Beyond the fact that the specimen was bifid at the posterior end no information is given concerning it.

Thus among the many hundred annelids carefully studied and among the thousands more or less casually observed there were found, as far as this imperfect record extends, only about twenty cases of bifid ends. Of these only two were cases of duplication of the head end. Only eight cases have been figured and these, as seen in the accompanying plate, leave much to be desired regarding the details of the bifurcations.

The period in which these monstrosities arose is not well known; whether they were present in the embryo or were formed in the maturer period of the individual's existence. Yet there is little support for the former supposition, while for the latter we have in two cases good evidence and in many others considerable presumption towards this conclusion. Thus the case shown in fig. 6 can hardly have arisen otherwise than as a consequence of the loss of a normal large head in which the normal pharynx could function. Again, the somewhat doubtful double-headedness of the annelid figured by Bonnet, figs. 7 and and 8, is explicitly stated by him to have arisen after the normal anterior portion had been cut off. Moreover a considerable number of the observed cases have been found while experimenting upon the power to reproduce lost parts.

Granting for the present that these monstrosities have arisen in late life after removal of parts of the main axis or after injuries, we may next enquire how far the two new ends are of equal or unequal value, whether, as figs. 2 and 4 would indicate, the two new parts are equal in origin or whether one, as in fig. 10, etc., is to be regarded as a subordinate part or lateral outgrowth from the main trunk. In both cases of double-headedness, figs. 6, 7, 8 the left is the more complete of the two heads; amongst the cases of bifid posterior ends three have the left more developed, one the right and two others an undetermined side exceeding the other. Only two, figs. 2 and 4, are known to have undoubtedly equal ends.

As far as the evidence goes (and it is too scanty to warrant binding conclusions), there is some indication that one of the heads or tails is a supernumerary part growing out, often on the right, as a somewhat imperfect duplication of the normal end or continuation of the main axis.

Whether the two branches are at first equal, as in fig. 2, and subsequently become unequal or, as seems probable in many cases, one is at first only a side bud on the main axis, cannot be determined as yet.

The interpretation of one of the two parts as a lateral outgrowth allies this process to that described by McIntosh (**15**) in the remarkable *Syllis ramosa.* This annelid lives inside of sponges and presents the anomaly that its buds, instead of being confined to the direction of the main axis, may be also lateral, so that branches and sub-branches arise and produce a complex system with many ultimate tips that may become liberated as sexual animals. How far this lateral budding may be in each case brought about in connection with injuries is not known, but there seems to be an intimate connection between injury and budding, and McIntosh remarks, "the body of the annelid appears to have a great tendency to budding—laterally, terminally and wherever a broken surface occurs."

If, in this remarkable Syllis, budding has been acquired as a result of power to regenerate lost parts, as has been urged by Lang and v. Kennel for other cases of budding among annelids, it is a recent and secondary process. Not so the regenerative power itself which is to be met with in a peculiar form in the double embryos of certain earthworms which arise, as claimed by Kleinberg and corroborated by Wilson, from a single egg. Still further back there seems to be in the ovum a double potentiality. Thus Hans Dreisch[1] claims to have produced complete larvæ from half eggs, that is that the egg, in the Echinus studied, might have formed two larvæ or two adults.

Whether then in the reproduction of lost parts we have the formation at *successive* periods of duplications of the main axis to replace those lost, or in the cases of bifurcation (interpreted as somewhat like lateral budding), we have the *simultaneous* formation of duplications of the main axis, in either case the important fact is that the egg-individual may exhibit a power of reproducing its main axial parts without a sexual process. The bifurcated monstrosities thus exhibit what may be a universally present but latent ability of parts of a highly organized animal to form a complete individual like that to which they belong.

Baltimore, Md., May 5, 1892.

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[1] See the AMERICAN NATURALIST, Feb., 1892, p. 178.

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15. McIntosh.—Challenger Reports, xii, 1885.

Explanation of Plate.

Fig. 1. *Ctenodrilus monostylos* x 12½. Zeppelin (**9**), pl. 36, fig. 18.

Fig. 2. *Salmacina incrustans.* Claparéde (**10**), pl. 30, fig. 5F.

Fig. 3. *Ctenodrilus monostylos* x 22½. Zeppelin (**9**), pl. 36, fig. 19; drawn from a living specimen; not that shown in fig. 1, above.

Fig. 4. Posterior end of *Lumbricus terrestris.* Robertson (**4**).

Fig. 5. Same as fig. 4, but cut open to show intestine and dorsal blood vessel.

Fig. 6. *Typhlosyllis variegatus,* with two new heads. Langerhans (**12**).

Fig. 7. Posterior part of a naiad cut into three pieces and forming two heads (?) Bonnet (**1**), pl. 1^2.

Fig. 8. Enlarged view of anterior end of fig. 7. Bonnet (**1**), pl. 1^2, fig. 16.

Fig. 9. *Procærea tardigrada,* non-sexual form with a male bud having two tails; drawn from nature.

Fig. 10. *Lumbricus terrestris,* drawn from living specimen. Bell (**5**).

Fig. 11. Posterior end, enlarged, of the left tail of fig. 9.

Fig. 12. Posterior end, enlarged, of the right tail of fig. 9.

Fig. 13. Same as fig. 10 but drawn while in another position.

Fig. 14. Same as figs. 10 and 13.